Investigation of 2007 Summer Extreme Precipitation Events Using an Integration of Observations and WRF Simulations

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Objectives

- **3 case studies to evaluate WRF and NAM performance in Oklahoma (OK) during summer 2007, using the NARR and OK Mesonet precipitation data.**

- **To validate the WRF classified convective and stratiform precipitation using the NEXRAD and OK Mesonet observations.**

Four Data Sets

Observations

- **OK Mesonet rain gauge network**

Reanalysis

- **NARR (North American Regional Reanalysis)**

Modeling

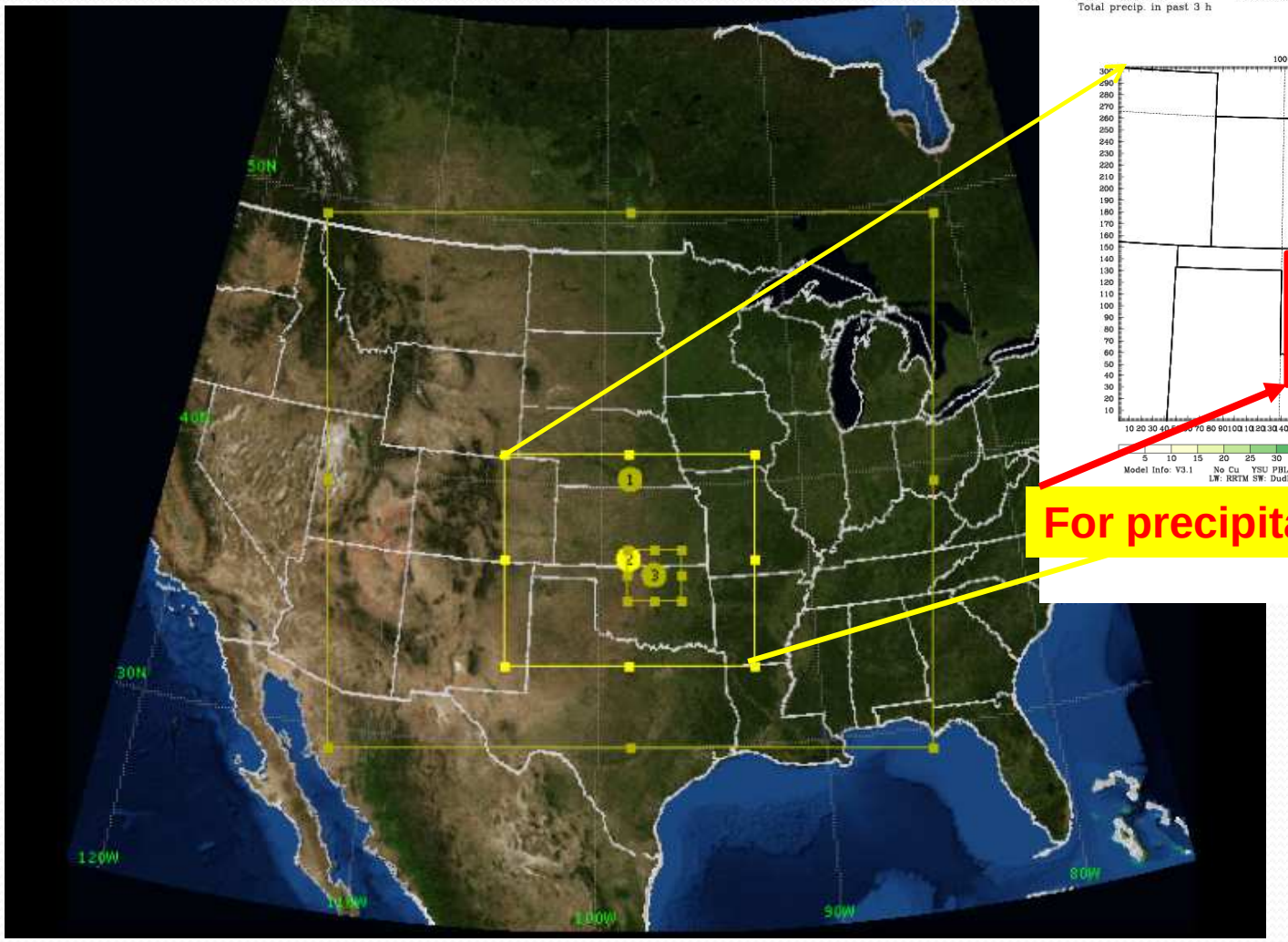
- **WRF 3.1.1 version**
- **NAM (North American Mesoscale Model)**

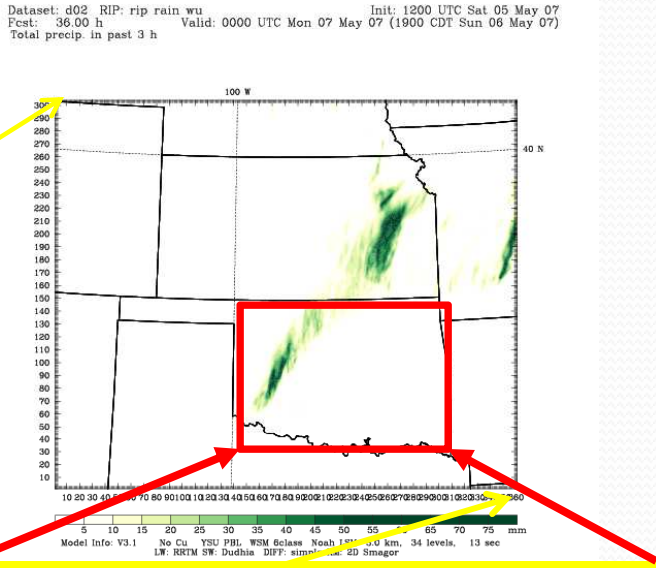
3 hourly accumulated precipitation.

Model Configurations

	WRF	NAM
Dynamic core	WRF-arw	WRF-nmm
Domain	3 nested domains from outermost US to innermost OK state	North American
Horizontal resolution (km)	9 km, 3 km, 1 km	12 km
Vertical levels	35	60
PBL parameterization	YSU	MYJ
Microphysics parameterization	WSM6	Ferrier
Cumulus parameterization	KF for the outermost domain, none for the rest	BMJ

Domain

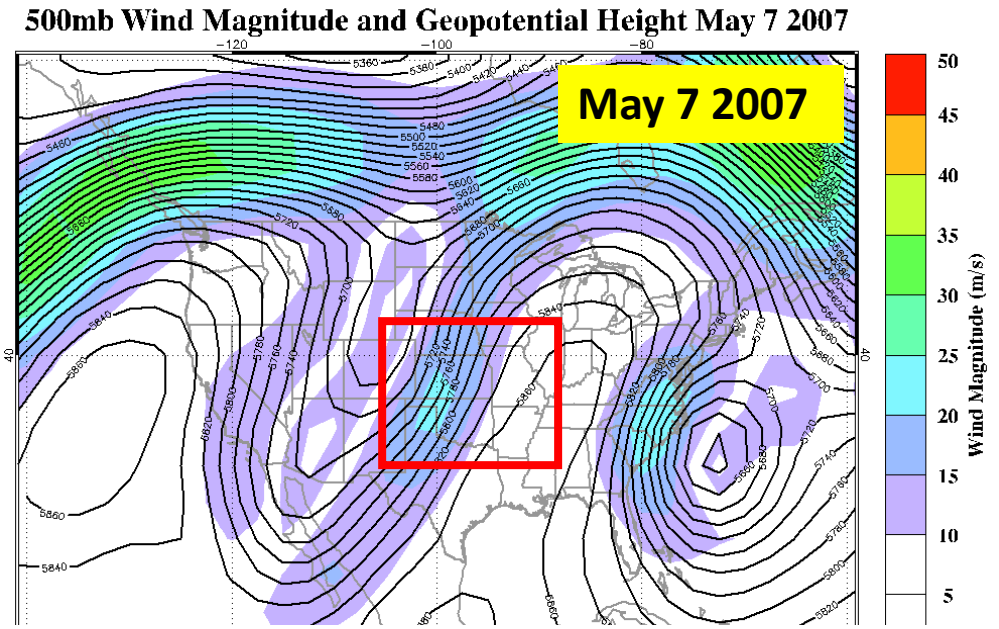


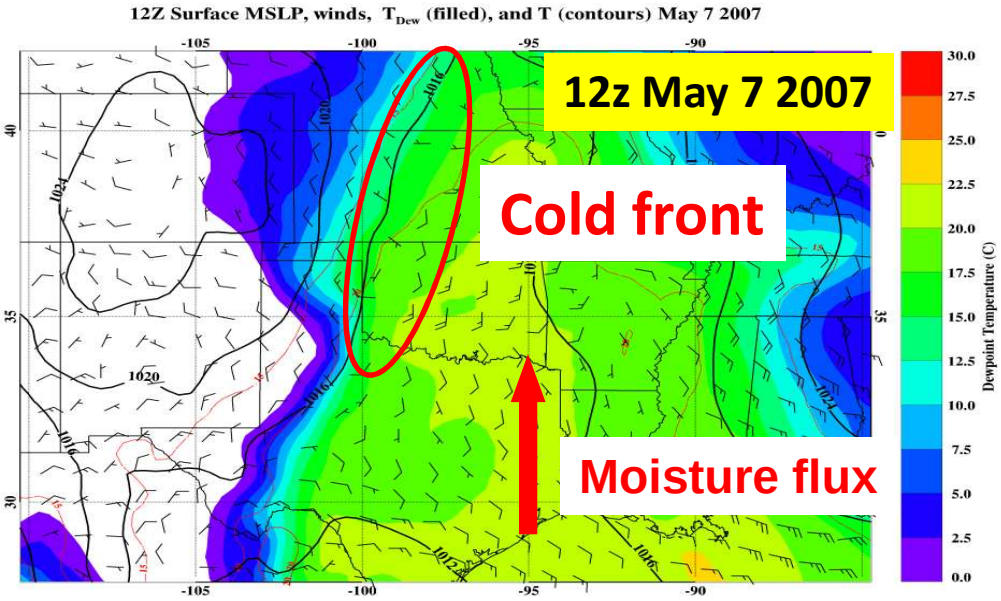


For precipitation comparison

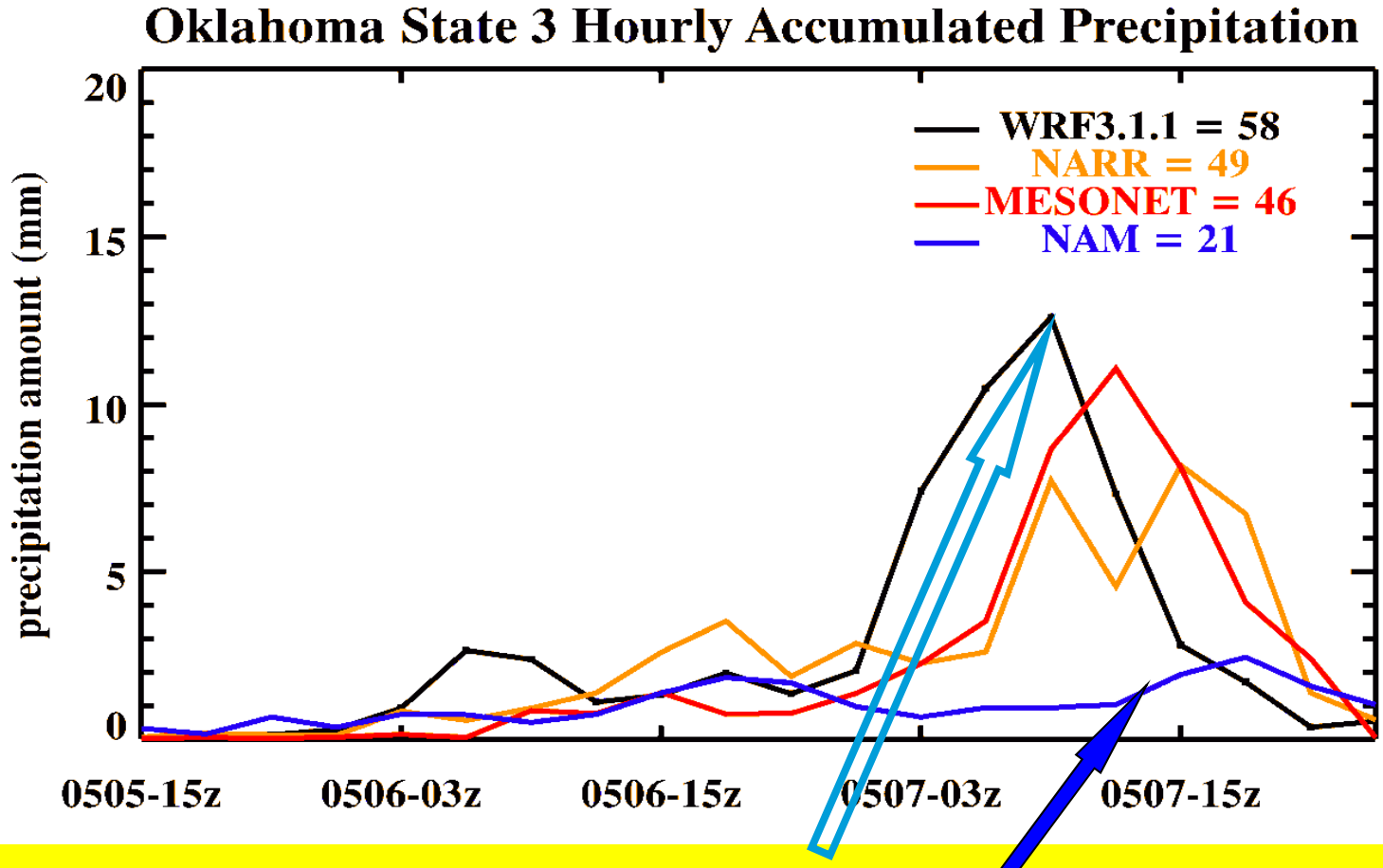
Synoptic pattern during May 6-7 (Case 1)

- **500 mb SW Trough**
- **LLJ, low level shear and low level moisture flux**
- **Squall line (06 22z-7 11z)**
- **MCS (07 11z-08 00z)**





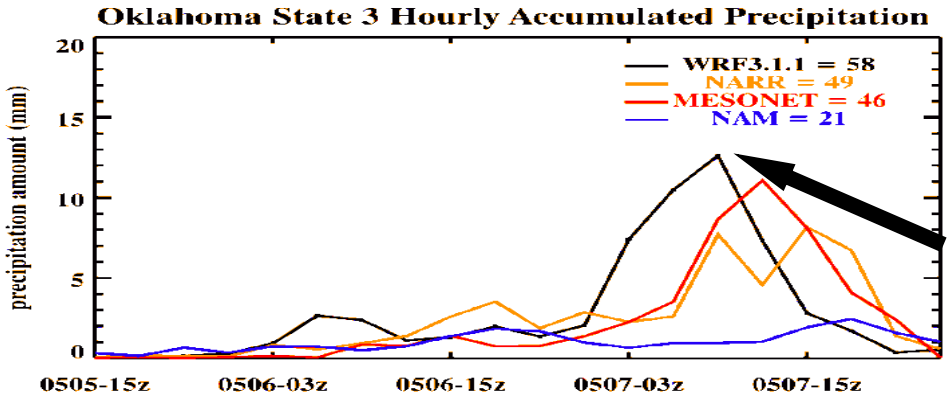
Case 1: 3-hr accumulated Precipitation



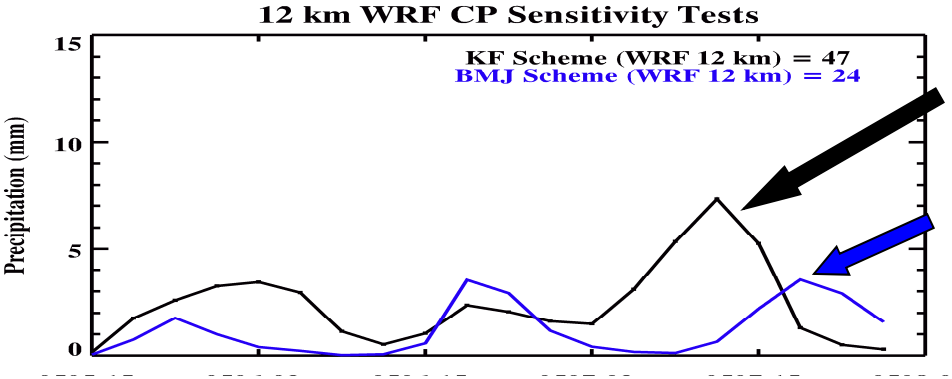
WRF: Precipitation started earlier than obs. The total precipitation was 12 mm more than obs.

NAM: under-estimated precipitation by more than 50%

Sensitivity to Horizontal resolution

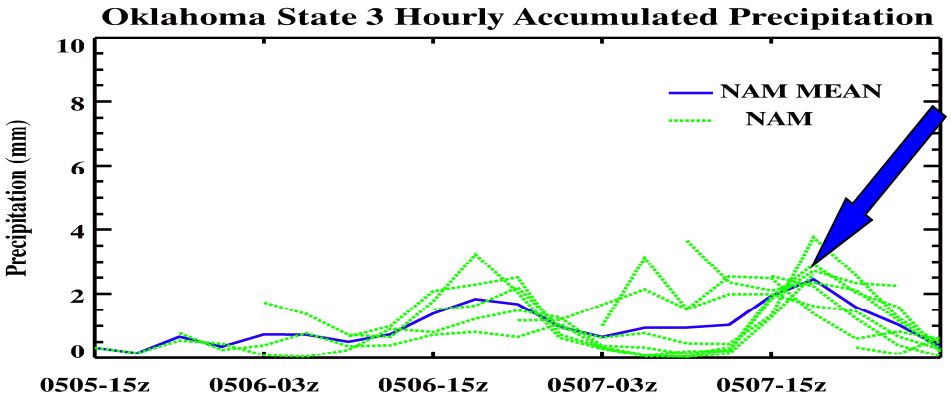


WRF : 3-km resolution



WRF with KF Scheme: 12-km resolution

WRF with BMJ Scheme: 12-km resolution



NAM ensemble mean: 12-km resolution

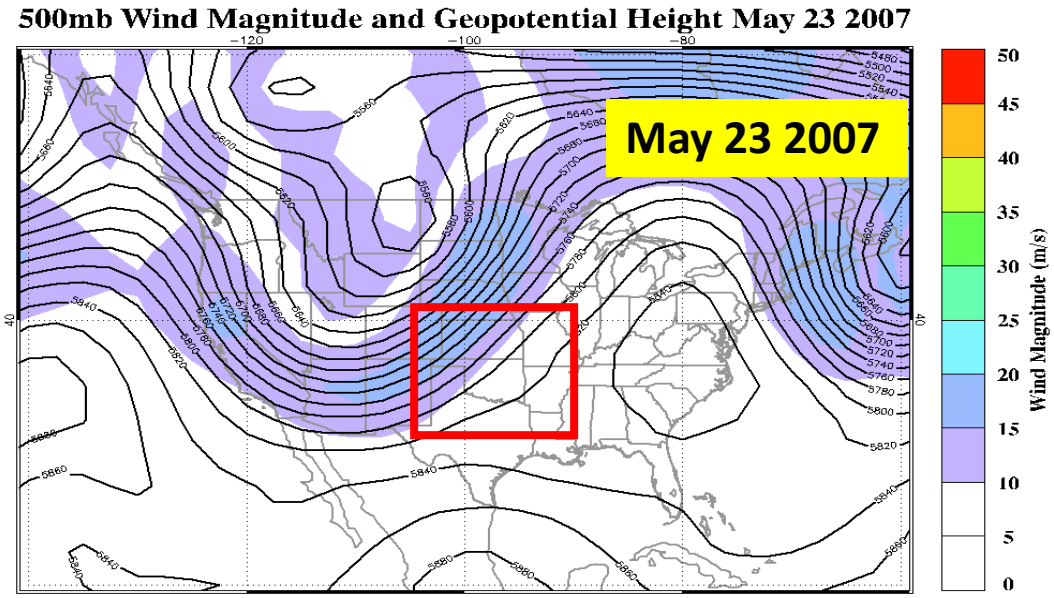
Conclusion: Horizontal resolution Is not the major factor. Simulation is more sensitive to different cumulus schemes.

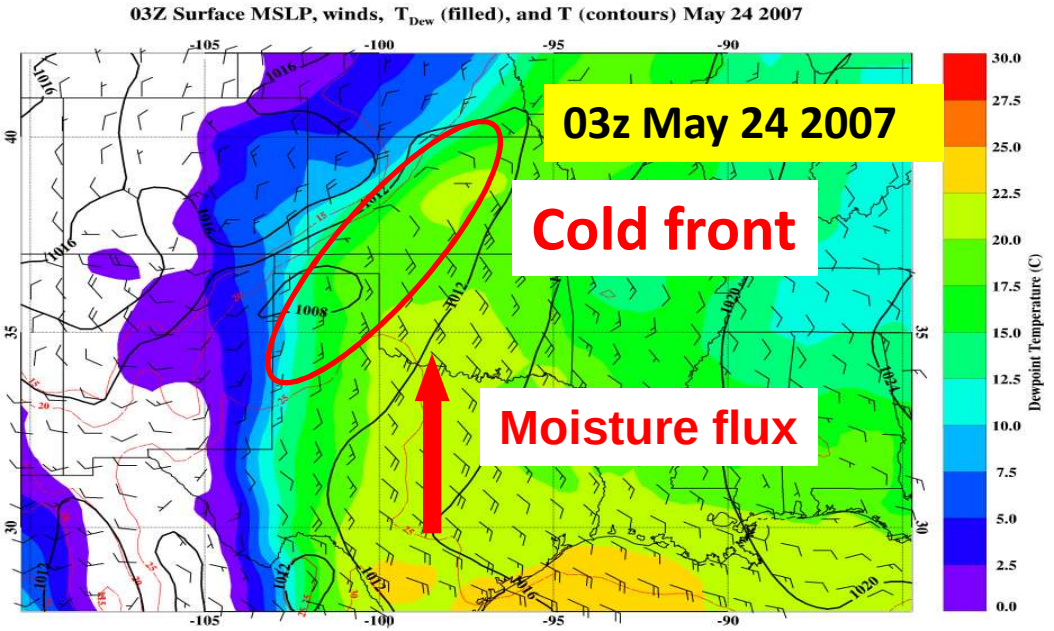
Summary of Case 1

1. **Based on observations, the major precipitation event started around 03z on May 7, and lasted until 00z on May 8 and is affected by short wave trough and cold front.**
2. **From WRF, precipitation reached the peak about 3 hour earlier than the observation and is overpredicting about 26% through the event.**
3. **Precipitation forecast from NAM missed the peak and significantly underpredicting about 50% of the precipitation.**
4. **horizontal resolution is not the major factor that causing the underpredicting problem. Simulation is more sensitive to cumulus schemes.**

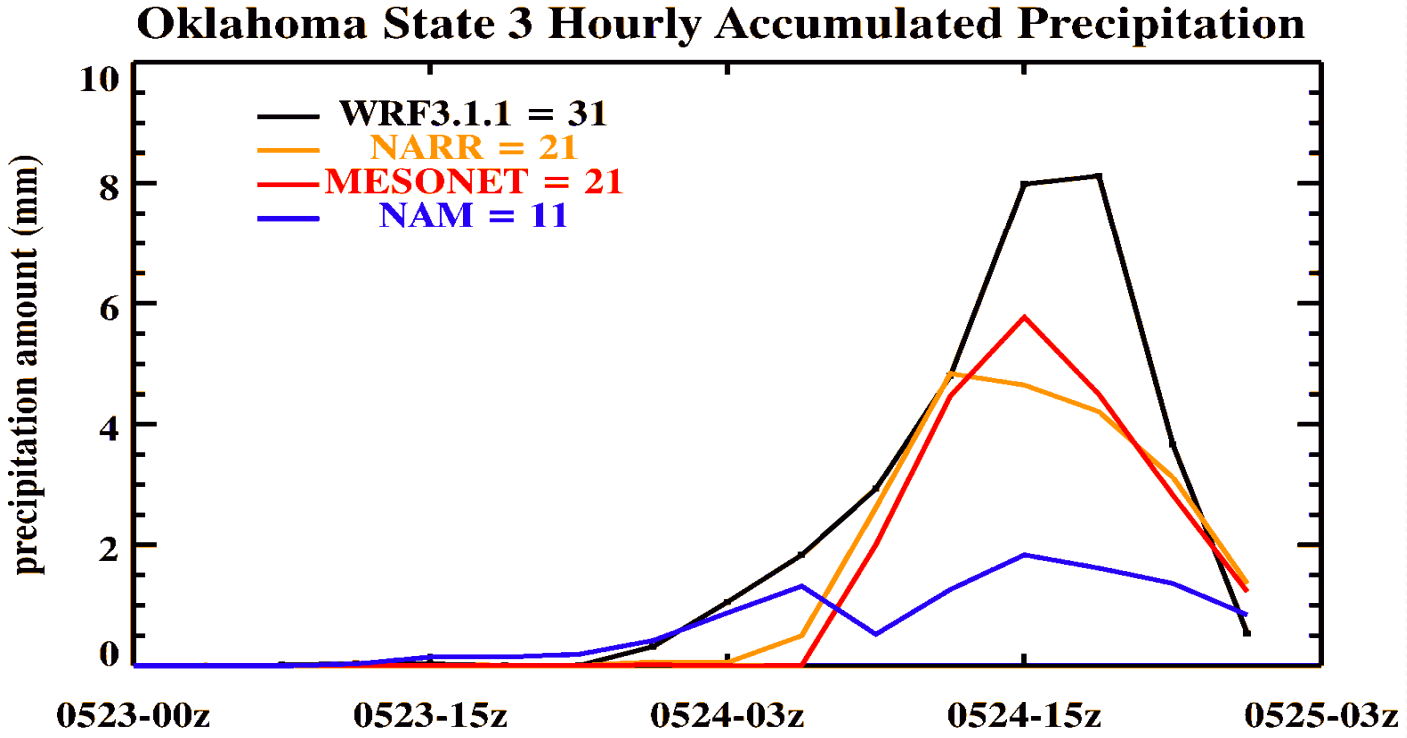
Synoptic pattern during May 24 (Case 2)

- 500 mb SW Trough
- Cold Front (24 00z-25 06z)
- Moist low level air mass
- Squall line (24 05z-19z)
- Storm scale and outflow boundary interaction





Case 2: 3-hr accumulated Precipitation



Compared to the Observations:

WRF: Over predicted the total precipitation by 50%

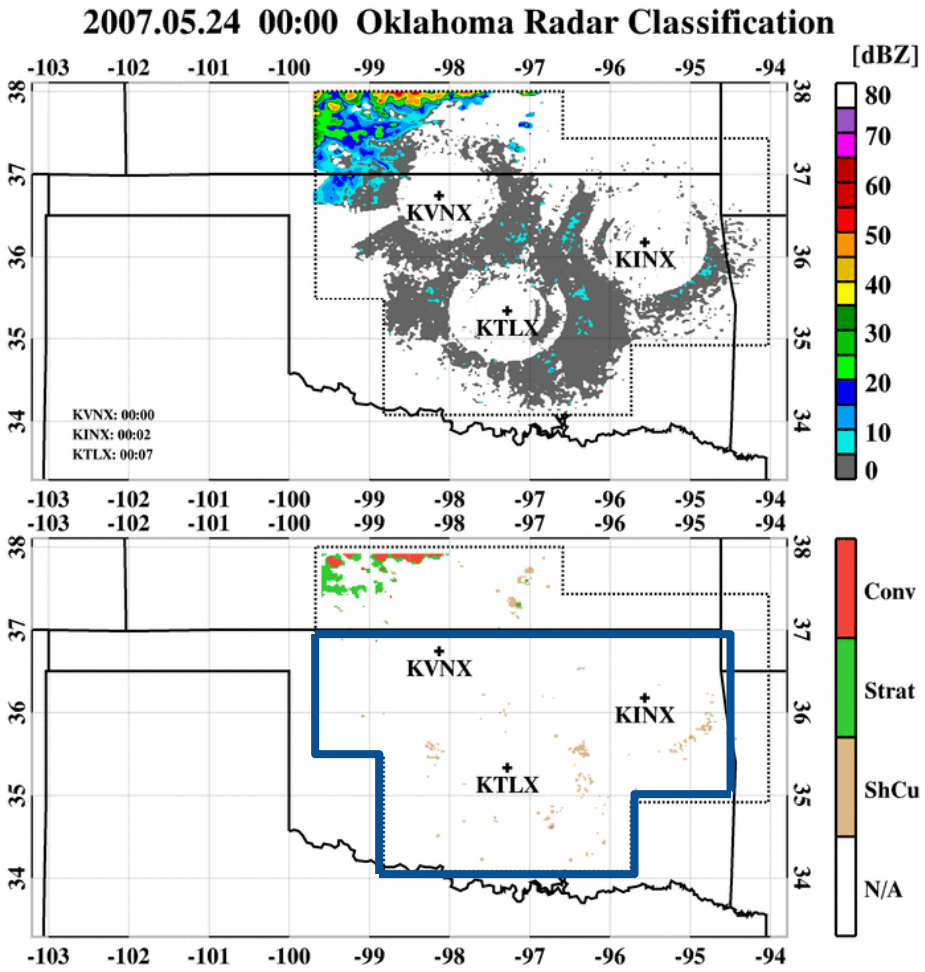
NAM: Under predicted the total precipitation by 50%

Whether it is the convective or stratiform cloud that lead to the over prediction problem?

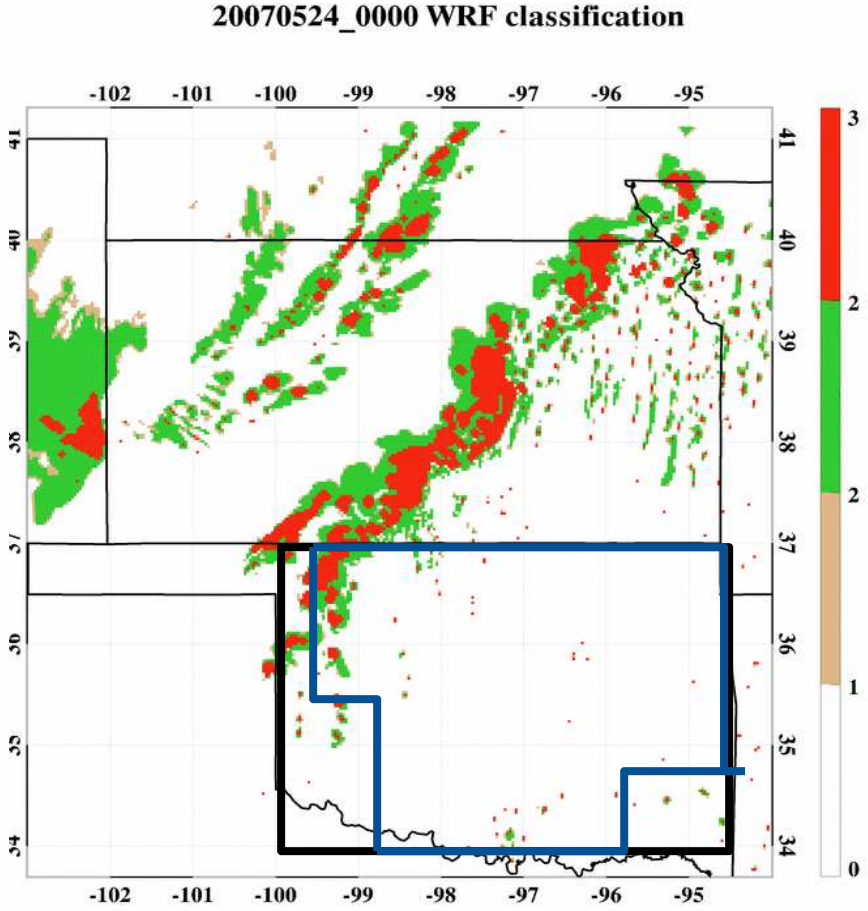
May 24

Comparison between radar and simulations

NEXRAD

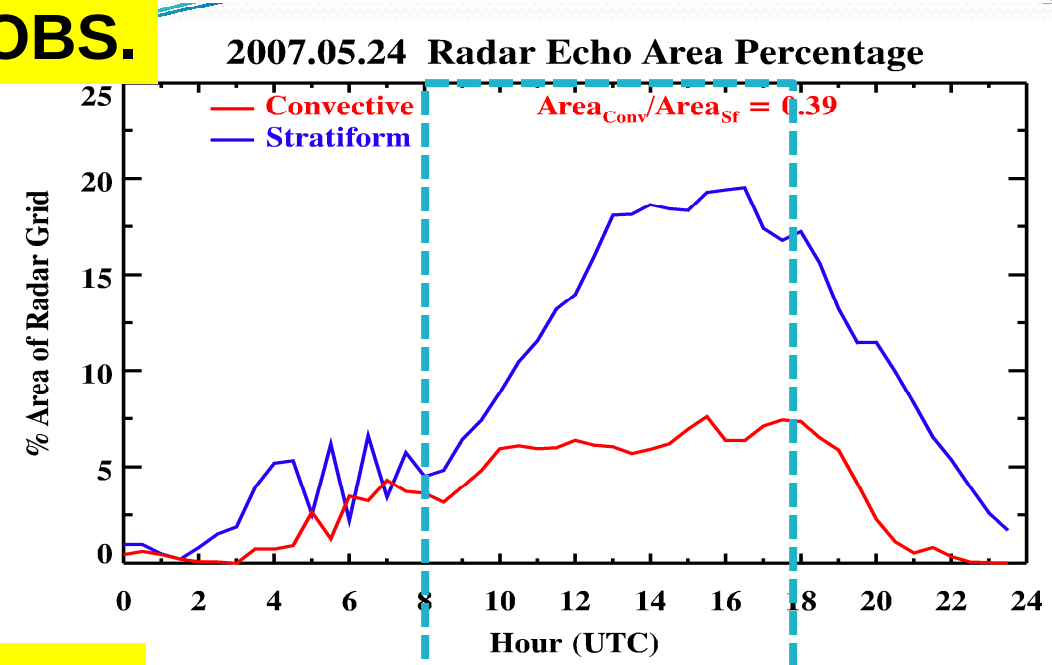


WRF

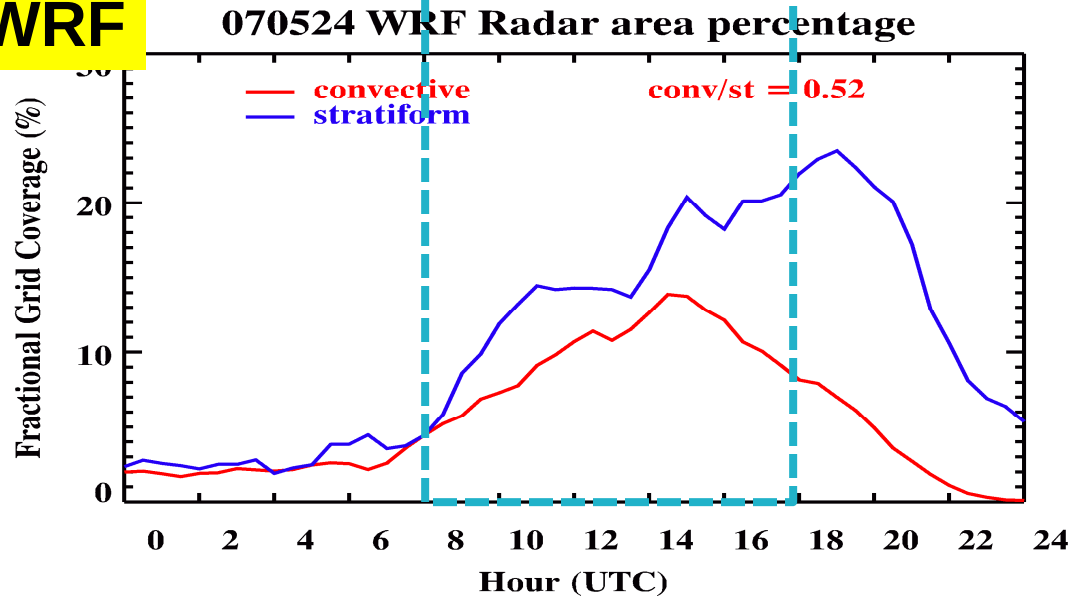


Case 2: Areas covered by Con. and Strat.

OBS.



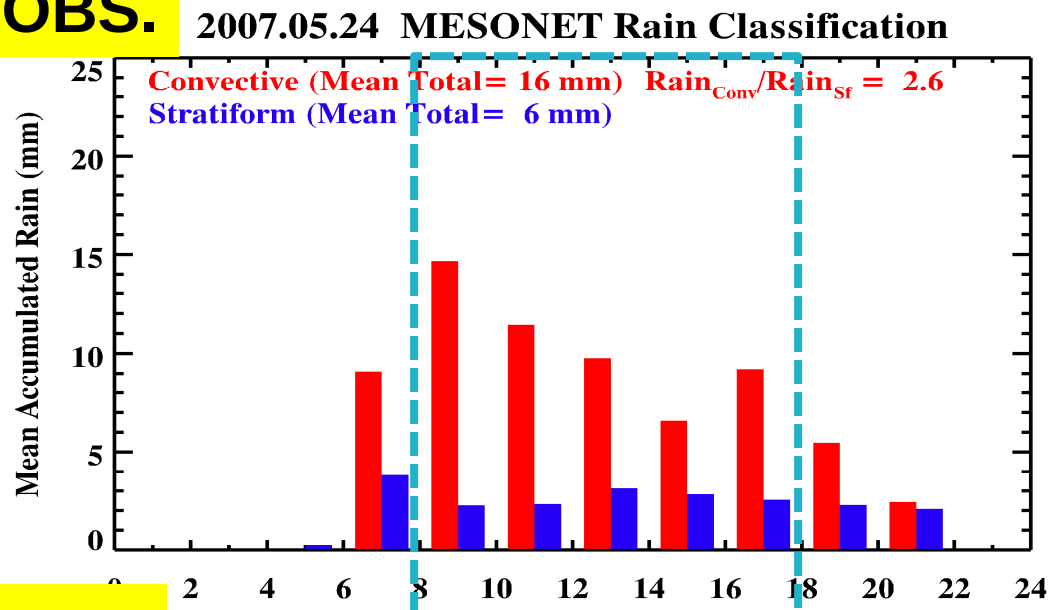
WRF



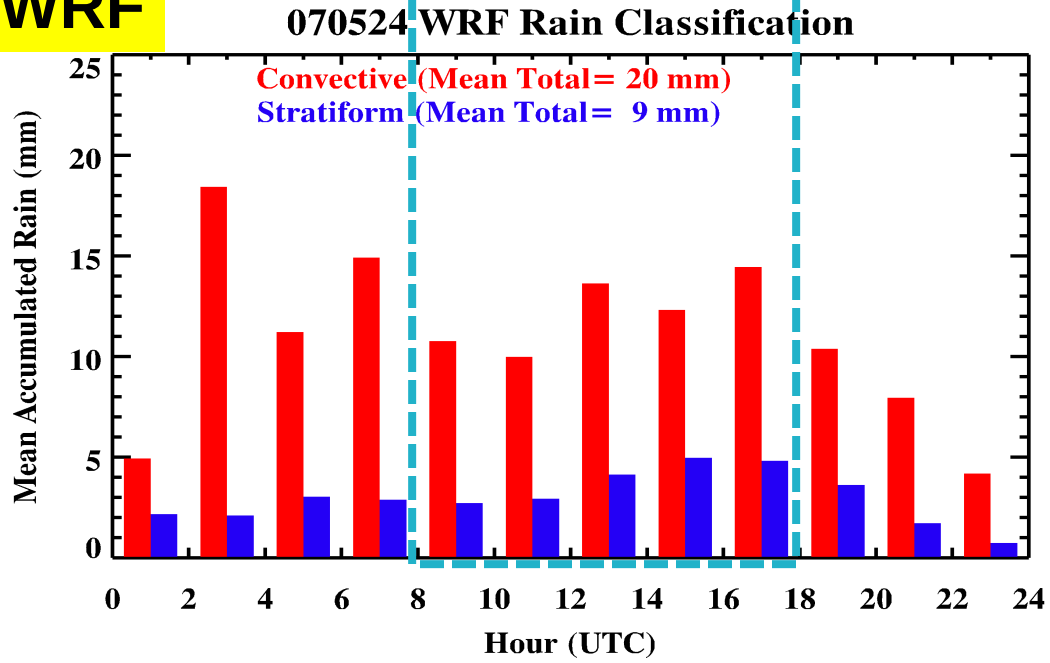
- **The box indicates the time period when NEXRAD and WRF are comparable.**
- **Stratiform cloud covers much larger area than convective cloud.**
- **In WRF simulations, it has greater ratio between convective and stratiform area coverage than obs.**

Case 2: Convective and Stratiform Precipitation

OBS.



WRF



- **Both obs. and WRF have shown that convective precip. is dominant (more than 2 times).**
- **It indicates whether model could capture the right convective feature is crutial to the total precipitation prediction.**
- **WRF overpredicting both convective and stratiform precip.**

Summary of Case 2

1. **Compared to the Observations:**

   WRF: Over predicted the total precipitation by 50%

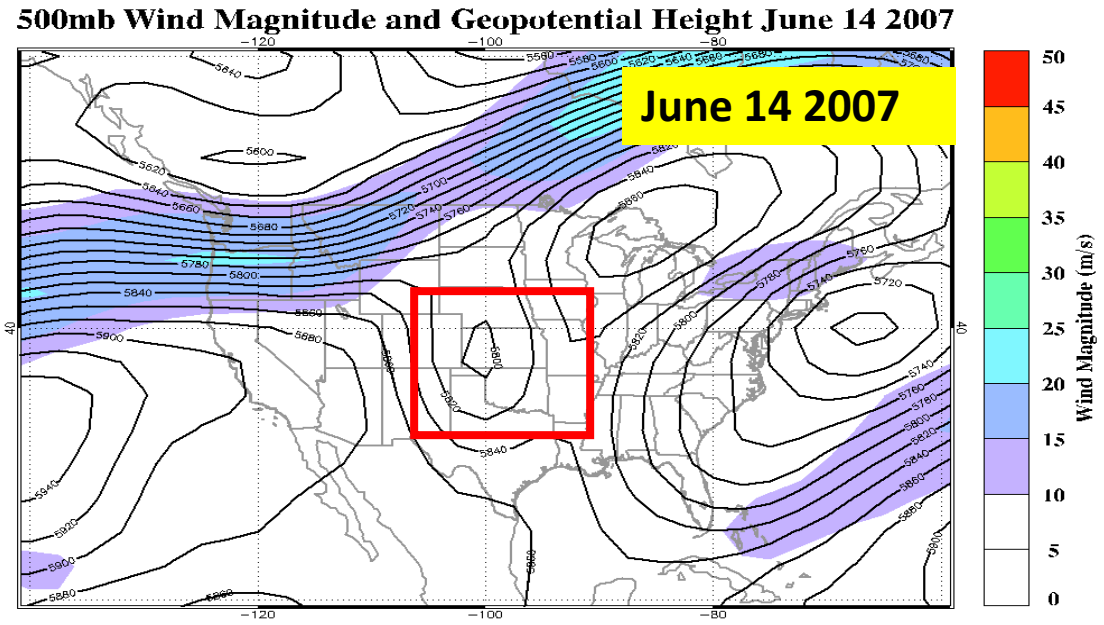
   NAM: Under predicted the total precipitation by 50%

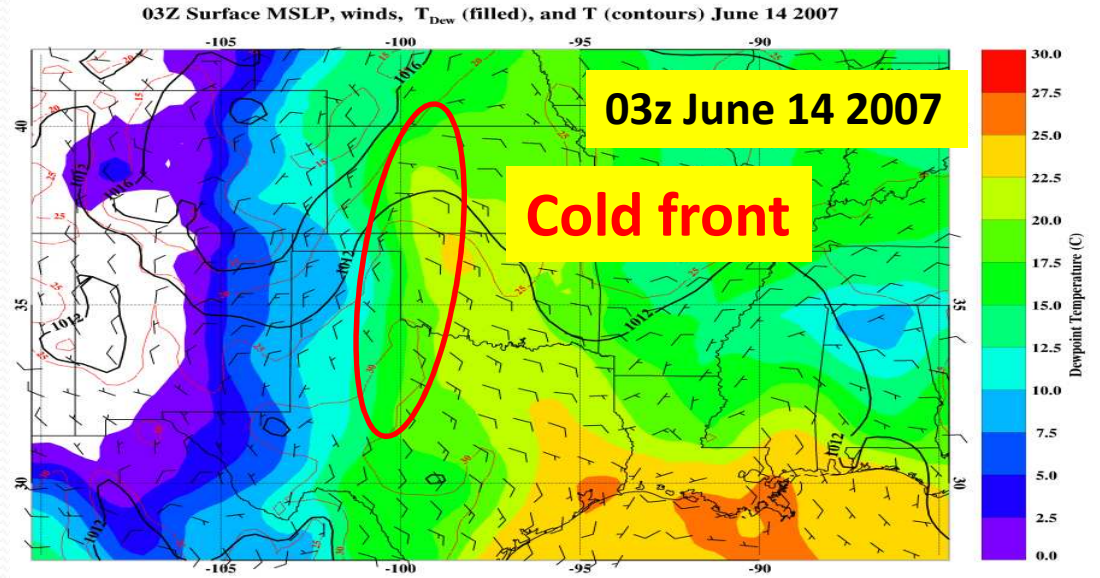
2. **Both NEXRAD and WRF simulations have shown that convective precipitation is dominant, while the Stratiform cloud covers much larger area than convective cloud.**

3. **WRF is overpredicting both convective and stratiform precip. , which caused the overall overpredicting problem.**

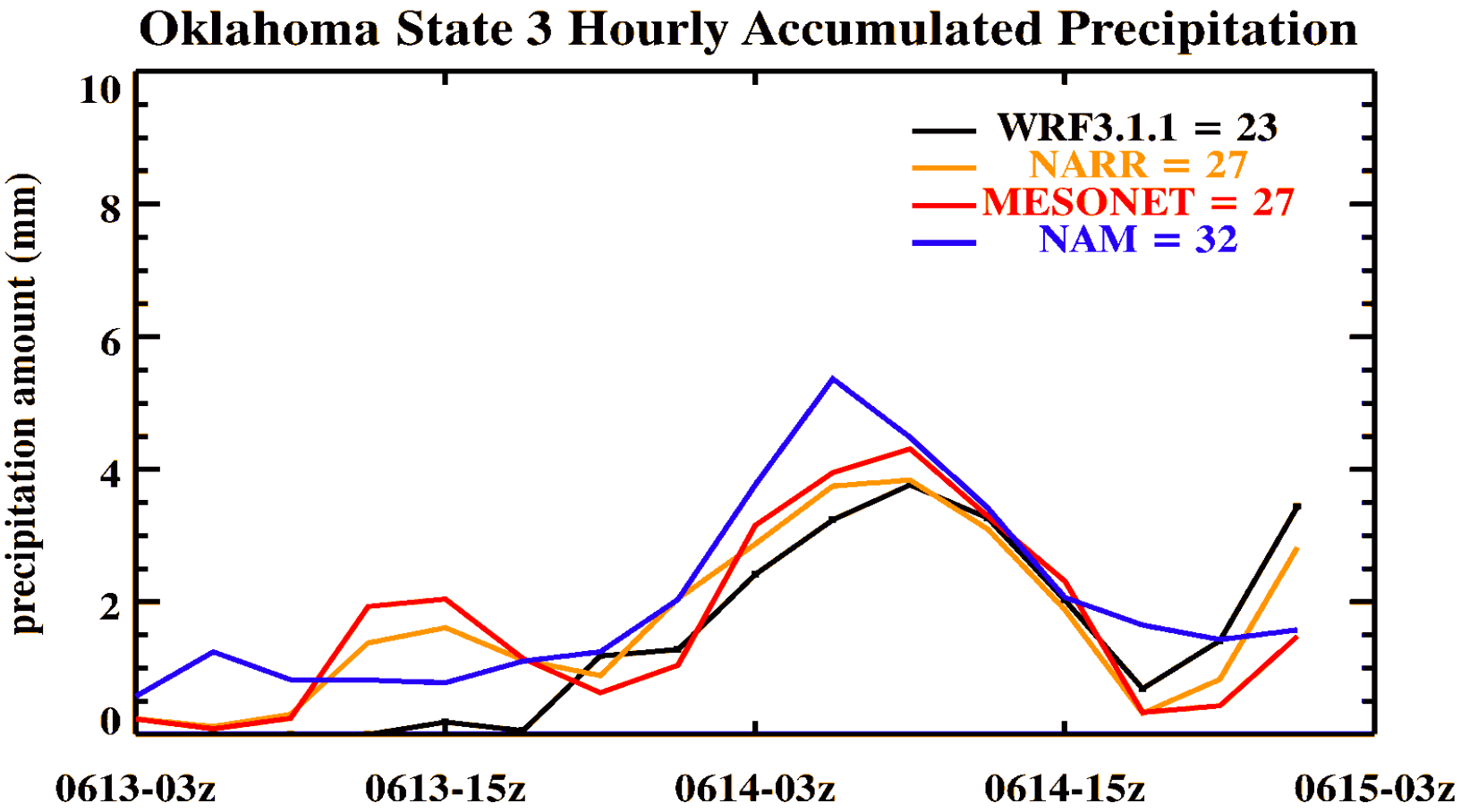
Synoptic pattern during June 14 (case 3)

- Cut-off low
- Cold/st front (13 09z-15 09z)
- dryline
- Outflow boundary
- MCS & SCT (14 03z-14 06z)





Case 3: 3-hr accumulated Precipitation

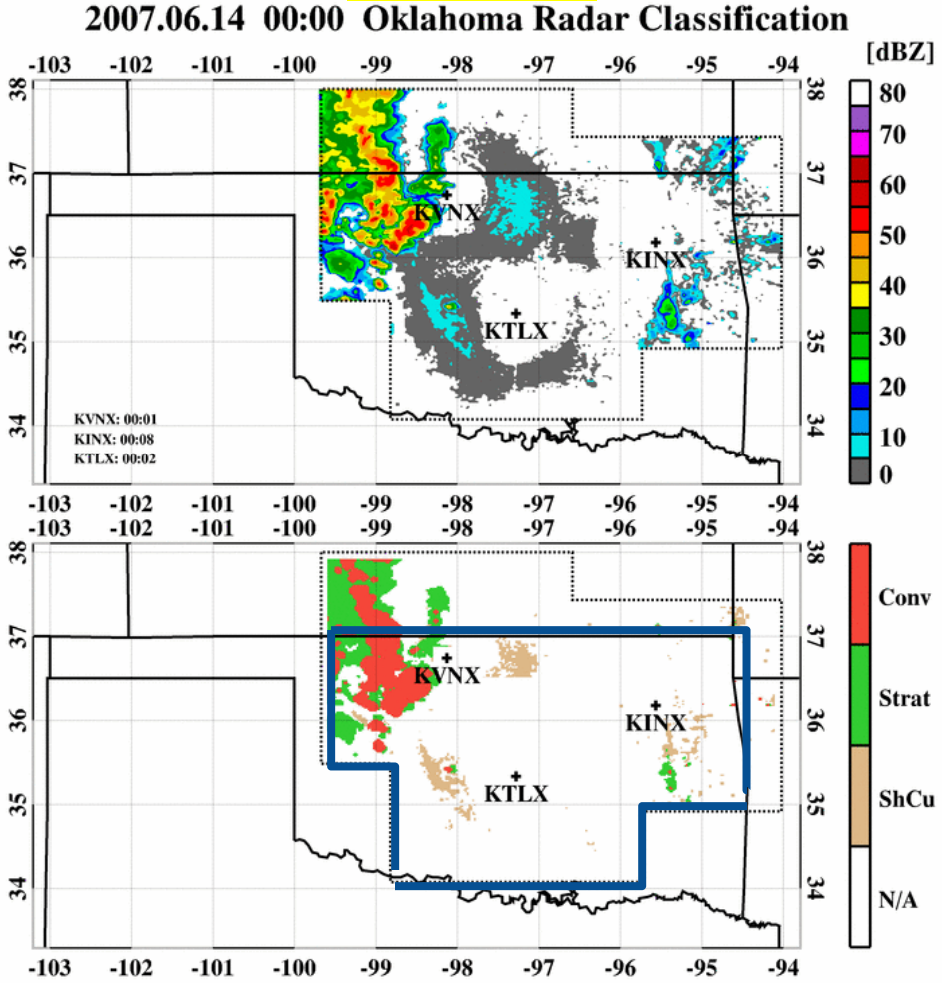


Compared to NARR and OK Mesonet Observations:

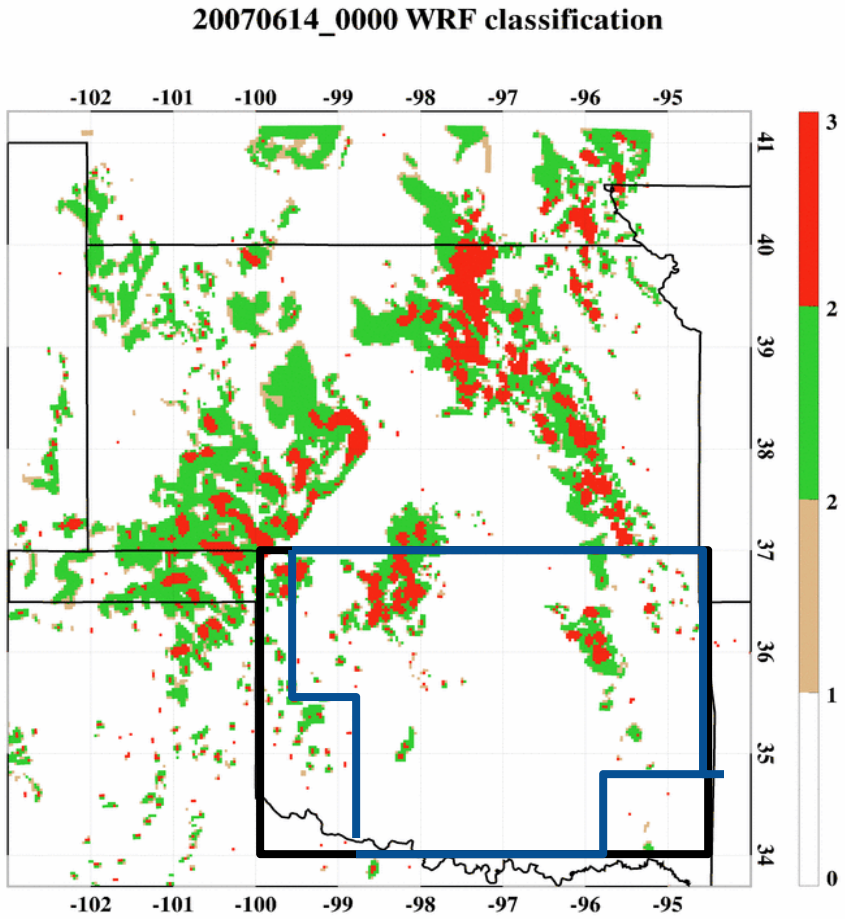
Both WRF and NAM did a good job in simulating the precipitation peak.

June 14

OBS.

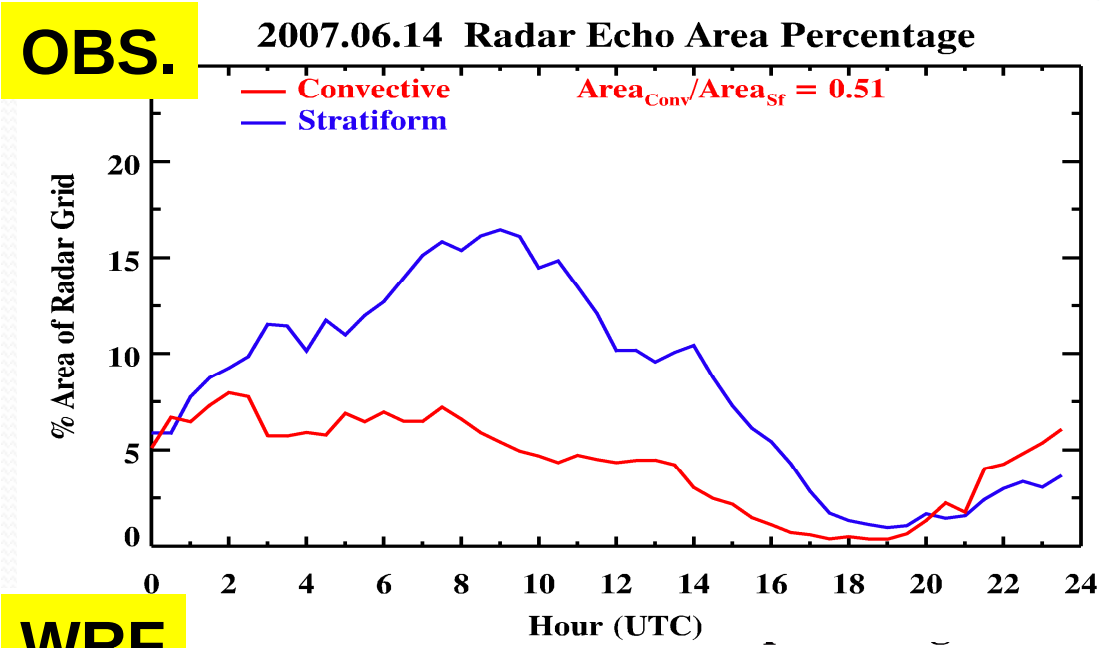


WRF

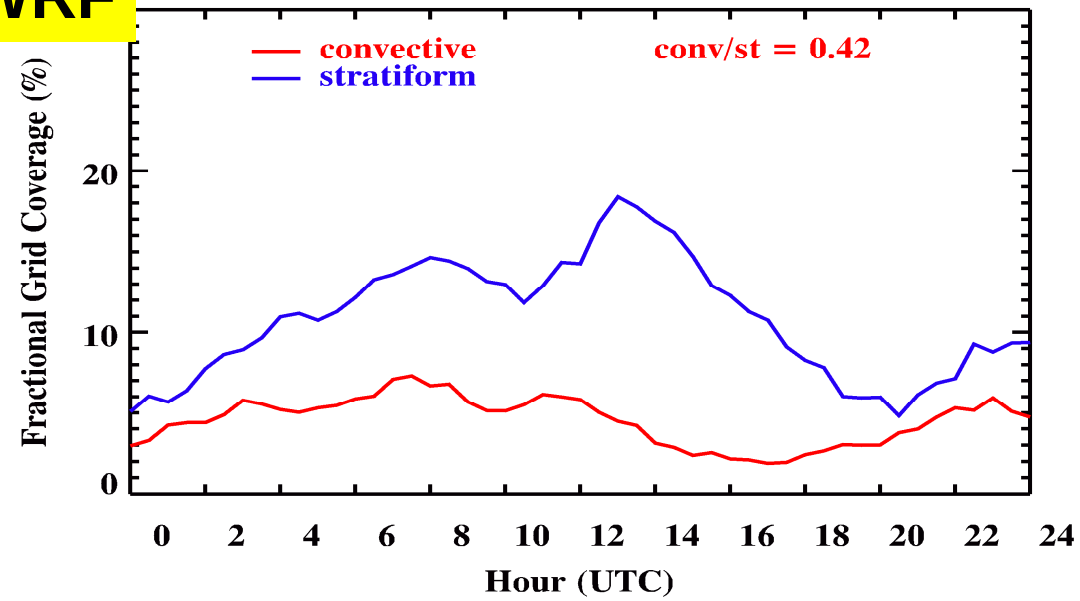


Case 3: Areas covered by Con. and Strat.

OBS.



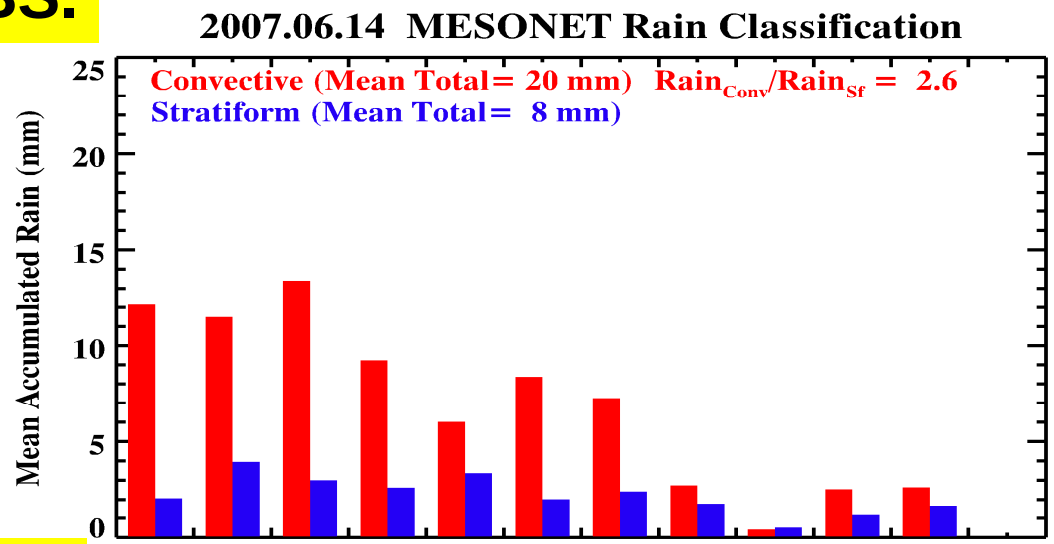
WRF



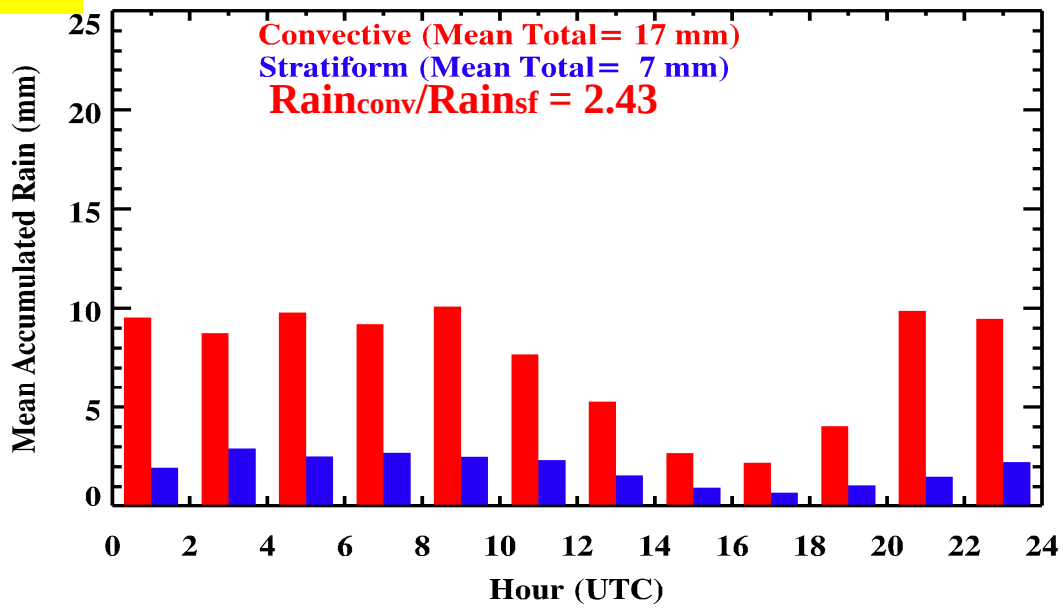
- **Same as the Case 2: Stratiform precipitation covers much larger area than convective precipitation.**
- **Close ratio of area coverage between WRF and obs.**

Case 3: Convective and Stratiform Precipitation

OBS.



WRF



- **Good agreement between observations and simulations.**
- **Same as the Case 2, convective precipitation is 2.5 times stratiform precip.**
- **WRF produced more convection from 20z to 24z**

Summary of Case 3

1. **Both WRF and NAM simulated precipitation agree very well with NARR and OK Mesonet observations.**

2. **WRF simulated convective and stratiform precipitation agree well with observations.**

3. **Same as the Case 2: Convective precipitation dominates, but Stratiform precipitation covers much larger area than convective precipitation.**

Conclusions

1. Compared to NARR and OK Mesonet observed precipitation, WRF overestimated and NAM underestimated precipitation in the Cases 1 and 2, but agree well in the Case 3.
2. Both observation and WRF have shown that Convective precipitation dominates, but Stratiform cloud covers much larger area than convective cloud.
3. As showed in case 1 sensitivity study, horizontal resolution is not the major factor that causing underpredicting problem. Simulation is more sensitive to different cumulus schemes.